



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification⁶ :B60C 11/11, 11/01, 11/00 // 103:00,
121:00

A1

(11) International Publication Number:

WO 99/52720

(43) International Publication Date:

21 October 1999 (21.10.99)

(21) International Application Number: PCT/US99/04533

(22) International Filing Date: 2 March 1999 (02.03.99)

(30) Priority Data:

29/092,741	26 August 1998 (26.08.98)	US
29/097,354	4 December 1998 (04.12.98)	US

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(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published

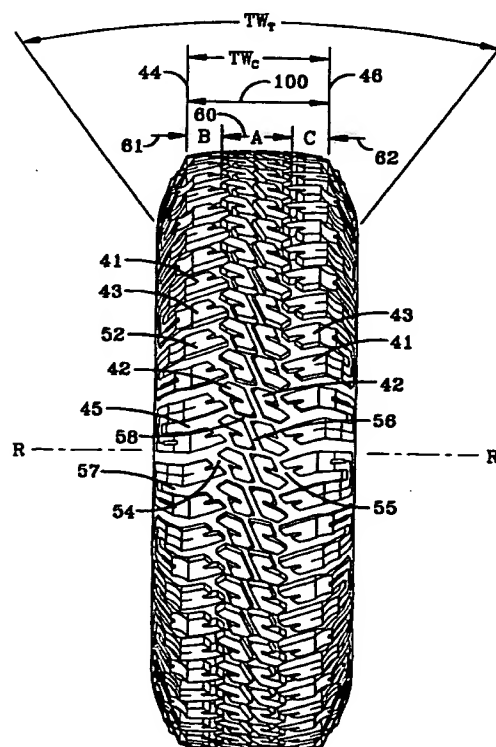
With international search report.

Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: AN ON/OFF-ROAD TREAD

(57) Abstract

An on/off-road tread (40) for passenger or light truck tire (10) has an off-road tread (40) including a central on road tread (100). The tread (40) extends from at or above a radial location of the maximum section width S_W of the tire (10) but less than a radial location of 65 % of the section height S_H of the tire (10).



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AN ON/OFF-ROAD TREAD

Technical Field

5 The following invention relates to a tread for a tire more specifically for a tread designed for road usage and off-road usage for passenger or light truck vehicles.

Background of the Invention

 Tires generally have a tread that is well-suited for a specific vehicle application. For example, pneumatic tires used primarily on paved surfaces generally have a high proportion of
10 the tread in contact with the road. These tires generally have a net-to-gross ratio in excess of 70%. This means that 70% or more of the area within the tires' footprint or contact patch is touching the road while 30% less is the void area representing the tires' grooves within the footprint area. These tires, due in part to the large amount of tread in contact with the road, can yield very good tread mileage sometimes in excess of 75,000 miles during the tires' normal life.

15 All season type tires can fall into this category of tires. All season tires have somewhat laterally extending grooves in each shoulder of the tread. These lateral grooves enhance snow traction performance.

 If, however, the vehicle owner wants increased traction on snow, tires having a more aggressive open tread pattern have been used for this purpose. These snow tires generally
20 have a lower net-to-gross ratio and almost always a large amount of leading edges on block elements to provide increased traction.

 When the vehicle owner wants a tire that can operate both on the roadways as well as in snow, mud and sand, he generally must select an on/off road tread.

 Typically, a serious off-road enthusiast may choose a tire designated as a mud tire.
25 These tires are very open, tending not to clog in the mud.

 In U.S. Patent No. 5,085,259, a tread pattern having a plurality of ground engaging block elements arranged in a directional tread pattern is disclosed. This patented tread pattern is employed on a commercially available tire sold as the Goodyear WRANGLER MT. The MT, mud tire designation has signified to off-road enthusiast that the tire was well-suited for
30 off-road applications. A measure of the tires' off-road worthiness was one of its first applications, the U.S. Army Hummer vehicle. This tread had excellent on/off road capabilities and throughout this patent application several references to testing will be made wherein the comparison or control tire is this prior art tire. As mentioned, the tread pattern of the WRANGLER MT was directional; that means that the tread pattern had a preferred
35 direction of travel. Traction capabilities of the tire are enhanced in the preferred direction of

travel. The most easily understood comparison is farm drive tires where the tread lugs pull the tractor through the soil. This non-directional feature means that the tire must have two sets of molds – one for each side of the vehicle. This increases tire costs.

Another problem associated with the very aggressive treads is that the high void areas means that when the tire is used on paved roads, the tread is very noisy, exhibits bad vibrational characteristics and has generally poor treadwear.

It is generally understood in the tire art that tread design is a matter of trade-offs aggressive off-road treads have to give up noise performance vibration and treadwear whereas good road tires are poor in off-road applications.

One of the objectives of the present invention is to provide an on/off road tread that has good on-road treadwear while showing excellent off-road traction.

Another objective is to design a non-directional tread with performance characteristics equal to or superior to the directional tread patterned tires.

Another objective of the invention is to design a tread that has a total tread width for off-road including a narrower road contacting central portion for on-road use.

These objective and other advantageous can be achieved by the inventive on/off tread for a tire as disclosed herein.

Disclosure of the Invention

Summary of the Invention

An on/off road tread (40) for a passenger or light truck tire (10) extending circumferentially about the axis of rotation R of a tire is disclosed. The tire (10) has a casing (12), a maximum section width S_w and a maximum section height S_H . The tread (40) has a plurality of block elements (41, 42, 43) projecting outwardly from the tire casing (12) from a location at or above a radial location of the maximum section width S_w of the tire (10), but less than 65 % of the section height S_w of the tire (10); a central portion (100) of the tread (40) being for on and off-road traction while the remainder of the tread (40) being for off-road traction.

The tread's central portion (100) is measured between first lateral edge (44) and second lateral edge (46). The distance halfway between the lateral edges (44, 46) defines the equatorial plane (EP) of the tire (10) which divides the tread into a first tread half (110) and a second tread half (120).

In the preferred embodiment of the invention within the central portion (100), the tread (40) has four rows (1, 2, 3, 4) of block elements (41, 42, 43) separated by three

circumferentially continuous grooves (54, 55, 56). The first tread half (110) has a first and second row. The first row (1) of shoulder block elements have an array of long block elements (41) extending from the first lateral edge (44) and circumferentially adjacent each long block element (41) is a short block element (43) offset axially inward from the first lateral edge (44). Each long and short block element (41, 43) has an axially aligned inner portions (74) divided by an inclined semi-blind groove (76), the semi-blind groove (76) extending less than halfway into each block element (41, 43).

A second central row (2) of block elements (42) are axially inward of the first row. The second row (2) has block elements (42) having an elongated circumferential shape extending inclined circumferentially from the equatorial plane toward an axially outer portion (77), the axially outer portion (77) is divided by an inclined semi-blind groove (78) circumferentially aligned but oppositely inclined relative to the semi-blind groove (76) of the adjacent shoulder block element (41, 43).

The second tread half (120) has a third row (3) and a fourth row (4), the third row (3) is the same as the second row (2), the fourth row being the same as the first row. Both the third row (3) and fourth row (4) being oppositely oriented relative to the respective first and second rows.

The on/off-road tread for a tire has the central portion of the tread divided into three tread zones (60, 61, 62) - a first shoulder zone (61), a second shoulder zone (62) and central zone (60). Each shoulder zone (61, 62) extends from a lateral edge (44, 46) to a circumferential centerline of a circumferential groove (54, 55). The circumferential centerline is defined as midway between peak amplitudes on each of the respective circumferential groove (54, 55, 56). The first and second shoulder zones (61, 62) preferably have equal net-contact areas while the central zone (60) has a net contact area greater than the first or second zones contact area, preferably at least 10% greater than a shoulder zone, more preferably the central zone (60), has a net-to-gross ratio greater than 50%.

The increased traction of the tread is achieved primarily from a plurality of block elements (41, 42, 43) that have a plurality of leading traction edges (50). The sum of the leading traction edges (50) of the tread (40) being at least 150% of the sum of the leading traction edges (50) of the central portion (100) of the tread (40).

Brief Description of Drawings

FIGURE 1 is a perspective view of the tire according to a preferred embodiment of the invention.

FIGURE 2 is a plan view of the tire of FIGURE 1.

FIGURE 3 is an enlarged fragmentary view of the tire of FIGURE 2.

FIGURE 4 is a cross-sectional view of the tire taken along line 4-4 of FIGURE 2.

FIGURE 5 is a side view of the tire of FIGURE 1.

5 FIGURE 6 is a graph of Performance Characteristics.

Definitions

For ease of understanding this disclosure, the following items are disclosed:

"Aspect ratio" of the tire means the ratio of its section height (SH) to its section width (SW) multiplied by 100% for expression as a percentage.

10 "Asymmetric tread" means a tread that has a tread pattern not symmetrical about the centerplane or equatorial plane EP of the tire.

"Circumferential" means lines or directions extending along the perimeter of the surface of the annular tread perpendicular to the axial direction.

15 "Equatorial plane (EP)" means the plane passing midway between the width of the tread and perpendicular to the tire's axis of rotation.

"Groove" means an elongated void area in a tread that may extend circumferentially or laterally about the tread in a straight, curved, or zigzag manner. Circumferentially and laterally extending grooves sometimes have common portions. The "groove width" is equal to tread surface area occupied by a groove or groove portion, the width of which is in question, divided
20 by the length of such groove or groove portion; thus, the groove width is its average width over its length. Grooves may be of varying depths in a tire. The depth of a groove may vary around the circumference of the tread, or the depth of one groove may be constant but vary from the depth of another groove in the tire. If such narrow or wide grooves are of substantially reduced depth as compared to wide circumferential grooves that they interconnect, they are regarded as
25 forming "tie bars" tending to maintain a rib-like character in the tread region involved.

"Inboard side" means the side of the tire nearest the vehicle when the tire is mounted on a wheel and the wheel is mounted on the vehicle.

"Lateral" means an axial direction.

30 "Net contact area" means the total area of ground contacting elements between defined boundary edges divided by the gross area between the boundary edges as measured around the entire circumference of the tread.

"Net-to-gross ratio" means the total area of ground contacting tread elements between the lateral edges around the entire circumference of the tread divided by the gross area of the entire tread between the lateral edges.

"Non-directional tread" means a tread that has no preferred direction of forward travel and is not required to be positioned on a vehicle in a specific wheel position or positions to ensure that the tread pattern is aligned with the preferred direction of travel. Conversely, a directional tread pattern has a preferred direction of travel requiring specific wheel positioning. "Axial" and "axially" means lines or directions that are parallel to the axis of rotation of the tire.

"Outboard side" means the side of the tire farthest away from the vehicle when the tire is mounted on a wheel and the wheel is mounted on the vehicle.

"Radial" and "radially" means directions radially toward or away from the axis of rotation of the tire.

"Rib" means a circumferentially extending strip of rubber on the tread which is defined by at least one circumferential groove and either a second such groove or a lateral edge, the strip being laterally undivided by full-depth grooves.

"Sipe" means small slots molded into the tread elements of the tire that subdivide the tread surface and improve traction.

"Tread element" or "traction element" means a rib or a block element.

Detailed Description of the Invention

With reference to FIGURES 1-5, a tire (10) having a tread (40) according to a preferred embodiment of the present invention is shown. The tread (40) when configured annularly has an axis of rotation R, first and second lateral edges (44, 46).

The tread (40) has a plurality of ground engaging traction elements (41, 42, 43) separated by circumferential grooves (54, 55, 56) and lateral grooves (57, 58). Each traction element (41, 42, 43) extends radially outwardly from a tread base (45) to a radially outer surface (52). The lateral grooves (57, 58) may preferably intersect and join to form a continuous lateral groove path across the entire tread width. Alternatively, the lateral grooves (57, 58) may begin or end at locations which are laterally or circumferentially spaced and never connecting, except that they may meet at a common circumferential groove (54,55).

The traction elements (41, 42, 43) as shown are block elements. The tread (40) as illustrated in FIGURES 1-5 has an on-road central portion (100) having an overall or total net-to-gross ratio of about 47% measured from tread lateral edge (44) to tread lateral edge (46). It is believed that the tire (10) can be successfully produced with treads (40) having a central

portion (100) having total or overall net-to-gross ratios between 40 % and 70 %, preferably 40 % to 50 %.

The central portion (100) of the tread (40) is divided laterally into three tread zones, (60, 61, 62). The central zone (60) is positioned between the two circumferential grooves (54, 55). The first shoulder zone (61) is located between the first lateral edge (44) and the first circumferential groove (54). The second shoulder zone (62) is located between the second lateral (46) edge and the second circumferential groove (55). The first or second tread zones (61, 62) are intended to be mounted on either the outer or outboard side of the vehicle (not shown) or on the inboard side. The first and second tread zones (61, 62) preferably have a net contact area less than the central tread zone (60). The central tread zone (60) preferably has a high net contact area greater than either the value of the first zone (61) or the value of the second tread zone (62). Each zone is defined as the area between specified boundary edges. The first zone (60) has boundary edges defined by two planes, one plane passing through the respective centerlines of each circumferential groove (54) and (55). The first zone (61) has boundary edges defined by the lateral edge (44) and a plane passing through the centerline of groove (54) closest in proximity to the lateral edge (44). The second zone (62) has boundary edges defined by the second lateral edge (46) and a plane passing through the centerline of the groove (55).

With particular reference to FIGURE 2, it can be seen that the central tread zone (60) has an average tread road contacting axial width A, the first tread zone (61) an average tread road contacting axial width B, and the second zone (62) an average tread road contacting axial width C. In the preferred embodiment, the axial width A is greater than B or C, and axial width B is equal to C. Also, groove (54) has an average axial width D while groove (55) has an average axial width E, E being preferably equal to D. These subtle features provide very specific and significant improvements. The central zone (60) when used on the lightly loaded rear wheel position of a light truck on paved surfaces bears most of the load. Zone (60) has the greatest axial width. The central zone (60) has a net-to-gross ratio of 50 %, preferably about 51 %, and an overall axial width equal to or greater than 40 %, preferably about 46 % of TW_c , TW_c being the tread width of the central portion (100). The first shoulder tread zone (61) has a net-to-gross ratio of about 40 %, preferably about 44 %, and an axial width of greater than 25 %, preferably about 27 % of TW_c . The second tread zone (62) similarly has a net-to-gross ratio of 44 % and an axial width of about 27 % of TW_c . Groove (54) has an average width D of about 7.0 % of TW_c and groove (55) has an average axial width E of 7.0 %

of the tread width TW. The wide groove (54) adjacent the second tread zone (61) is about equal in width to the opposite wide groove (55) adjacent the third zone (62). This feature permits the second and third zones (61, 62) to exhibit relatively high net-to-gross ratios improving wear and noise while maintaining the overall traction performance. In the development tire having a 33x12.5R15 size, a very important feature is demonstrated that further enhances uniform treadwear and improved traction. The actual contact area A of the middle zone (60) is $46\% \times TW_C \times \pi \times \text{diameter of the tread} \times 51\%$. This relationship yields a contact area in the central zone (60) that is greater than the second or third zones (61, 62) by more than 20%. Therefore, the zone (60) has a net-to-gross ratio greater than zone (61 and 62) by about 10% yet due to its increased width has a road contacting area greater than the zones (61 and 62) by preferably at least 20%.

With reference to FIGURES 1-3, the tread is divided into four rows (1, 2, 3, 4) of block elements (41, 42, 43), each row (1, 2, 3, 4) being separated by a circumferentially continuous groove (54, 55, 56). The first shoulder row (1) of block elements are arranged with laterally elongated block elements (41, 43), one long block element (41) extending from a first lateral edge (44) axially inwardly. Adjacent each long block element is a short block element (43). The short block elements (43) have an axially outer end (71) offset and spaced axially inward from the lateral edge (44). Both the long block element and the adjacent short block element (43) extend axially inwardly to axially inner end (70, 72), the respective inner ends (70, 72) being similar in shape and orientation and preferably are axially aligned. The block elements (41, 43) have an axially inner portion (74) divided by an inclined semi-blind groove (76).

The second row (2) of block elements (42) are circumferentially elongated extending axially outwardly from the equatorial plane (EP) to an axially outer portion (77) divided by a semi-blind groove (78), the semi-blind groove (78) being circumferentially aligned but oppositely inclined relative to an adjacent semi-blind groove (76) of the shoulder block elements (41, 43). As further illustrated, the corners (80) of the block elements (42) having acute included angles are chamfered.

The third row (3) of block element (42) are preferably the same in appearance overall shape of those of row (2) but oppositely oriented. Similarly, the fourth row of shoulder block elements preferably has the long elements (41) and the short elements (43) the same in appearance and shape as those in the first row, the first and second rows (1, 2) lie in-between

the first lateral edge (44) and the equatorial plane (EP) while the third and fourth rows (3, 4) lie in-between the second lateral edge (46) and the equatorial plane (EP).

As will be readily appreciated, the net contact area of the traction elements (41, 42, 43) between the lateral edges (44, 46) provide the on-road tread central portion (100).

5 This central portion (100) provides excellent wear characteristics without sacrificing off-road performance. A key feature of this tread (40) is that it extends well beyond the lateral edges (44, 46).

As shown in FIGURE 4, the tire (10) preferably has a casing (12) having one or more plies (20) extending from an annular tensile member (24) through the sidewall and radially inward of the tread (40) to an opposite annular tensile member (24). Interposed between the plies (20) and the tread is a belt reinforcing structure (30) having at least two layers of cord reinforced layers. Radially inward of the plies (20) is an air impervious liner (35). Radially inward of the bead a fabric toe guard (25) may be employed. A bead apex (26) lies above the annular tensile members (24). These components generally comprise the elements needed to form a tire.

15 In the practice of this invention, various rubber compositions may be used for the tire sidewall. Representative of such composition comprise, for example, a blend of natural rubber and cis 1,4-polybutadiene which contain, as a reinforcement, a combination of carbon black and precipitated silica together with a coupling agent (for example, see U.S. Patent Serial No. 09/159,663 filed September 24, 1998).

As can be seen in the cross-sectional view of FIGURE 4, the traction elements (41, 43) begin at a location at or above the radial location of the maximum section width and accordingly define the total tread width TW_T . The elements (41, 43) protrude outwardly from casing or tread base (45) of the tire (10) and provide additional traction leading edges (50) for off-road applications such as mud, sand, or snow. These additional traction edges (50) provide at least 150% more leading edges in the tread (40) when compared to the leading edges (50) of the on-road central portion (100 of the tread (40)). The overall net-to-gross ratio of the tread as measured in the TW_T zone is at least 50%, preferably about 53.8%. The areas between the edges of the tread (44, 46) to the radially innermost portion of the tread being 58%.

Preferably, these protruding traction elements (41, 43) extend radially to a location 65% or less of the section height S_H of the tire (10). Unlike most shoulder treatments found in

the upper sidewall of a tire that blend into the tire's sidewall, the traction elements (41, 43) of the present invention are protruding outwardly and are truly part of the tread (40).

Due in part that these sidewall protruding portions of the tread (40) only work in soft off-road applications, it has been determined that the traction elements (41, 43) need only extend outwardly a distance about 1/4 of the non-skid depth of the tread (40) as measured in the central portion (100). This amount of area extending outwardly from the tread (40) greatly enhances off-road traction.

As illustrated in FIGURE 5, each shoulder block element (41, 43) preferably extends over the tread's shoulder down the sidewall as described above. In the preferred embodiment, one adjacent long block element (41) and a short block element (43) are connected by a circumferentially extending portion (49). This preferred feature ties the traction elements (41, 43) together enhancing the sidewall stiffness and creating a particularly durable traction feature.

A primary benefit of the tread design of the present invention is that the central portion (100) of the tread (40) is of a finite and limited area. Thus, to increase on-road treadwear, performance meant that off-road performance would be sacrificed. By providing the on-road central area (100) with the added tread width beyond each lateral edge (44, 46) along the sidewalls as described above meant that both on-road wear and off-road traction could be improved. Not only could the performance be improved, the present invention makes it possible to achieve these improvements without requiring a directional tread pattern.

The following test data compares the present invention tire to the WRANGLER® MT. tire.

The graphical presentation illustrated in FIGURE 6 shows the prior art directional tire described in U.S. Patent No. 5,085,259, commercially sold as the Goodyear WRANGLER® MT tire used as a control tire. In each category, the control tire is set at a 100% level. A most interesting feature is that when the test tire was new, its tread noise ranked 91% of a new "MT" tire meaning it was noisier than the control tire. At 25,000 miles into the testing, the test tire tread noise level ranked 121% of the control tires or substantially quieted.

In every other category, the test tire was equal to or superior to the control tire. Most noteworthy was the tremendous gains of 174% in treadwear testing while also gaining in traction in conditions of wet, snow, mud, gravel, and grass conditions. These benefits are most remarkable, particularly in a non-directional tire of the present invention in view of the directional pattern employed in the control tire.

While certain representative embodiments and details have been shown for the purpose of illustrating the invention, it will be apparent to those skilled in this art that various changes and modifications may be made therein without departing from the spirit or scope of the invention.

CLAIMS

1. An on/off-road tread (40) for a passenger or light truck tire (10) extending circumferentially about the axis of rotation of a tire, the tire (10) having a casing (12), a maximum section height S_H and maximum section width S_w , the tread (40) having a plurality of
5 block elements (41, 42, 43) extending from and projecting outwardly from the tire casing (12), from a radial location at or above a radial location of the maximum section width S_w of the tire (10) but less than 65 % of the section height S_H , a central portion (100) of the tread (40) being for on and off-road traction while the remainder of the tread (40) being for off-road traction.
2. The on/off-road tread (40) for a passenger or light truck tire of claim 1 wherein the tread
10 central portion (100) is measured between a first and second lateral edges (44, 46), the distance halfway between the lateral edges (44, 46) defining the equatorial plane EP of the tire (10), and dividing the tread (40) into a first tread half and a second tread half within the central portion (100), the tread (40) having four rows (1, 2, 3, 4) of block elements (41, 42, 43) separated by three circumferentially continuous grooves (54, 55, 56), the first tread half having the first row
15 (1) and second row (2), the first row (1) of shoulder block elements having an array of long block elements (41) extending from the first lateral edge (44) and an adjacent short block element (43) offset axially inward from the first lateral edge (44), each long and short block element (41, 43) having an axially aligned inner portions (74) divided by an inclined semi-blind groove (76), the semi-blind groove (76) extending less than halfway into each block element (41, 43), a second
20 central row (2) of block elements (42) has an elongated circumferential shape extending inclined circumferentially from the equatorial plane EP toward an axially outer portion (77), the axially outer portion (77) being divided by an inclined semi-blind groove (78) circumferentially aligned but oppositely inclined relative to the semi-blind groove (76) of the adjacent shoulder block element (41, 43), the second tread half having a third row (3) and a fourth row (4), the third row
25 (3) being the same as the second row (2), the fourth row (4) being the same as the first row (1), both the third and fourth rows of block elements (41, 42, 43) being oppositely oriented relative to the respective first and second rows.
3. The on/off-road tread (40) for a passenger or light truck tire (10) of claim 1 wherein the central portion (100) of the tread (40) is divided into three tread zones (60, 61, 62), a first
30 shoulder zone (61), a second shoulder zone (62) and a central zone (60), each shoulder zone (61, 62) extending from a lateral edge (44, 46) to a circumferential centerline of a circumferential groove (54, 55). The circumferential centerline being midway between peak amplitudes on each side of the groove (54, 55), the first shoulder zone (61) and the second shoulder zone (62) having

equal net-contact areas and the central zone (60) having a net-contact area greater than the first or second contact area.

4. The on/off-road tread (40) for a passenger or light truck tire (10) of claim 3 wherein the net-to-gross contact ratio of each shoulder zone (61, 62) is less than the net-to-gross ratio of the central zone (60), the central zone (60) is at least 10% greater than a shoulder zone (61, 62).
5. The on/off-road tread (40) for a passenger or light truck tire (10) of claim 3 wherein the plurality of block elements (41, 42, 43) have a plurality of leading traction edges (50), the sum of the leading traction edges (50) of the tread (40) being at least 150% of the sum of the leading traction edges (50) of the central portion (100) of the tread (40).
- 10 6. The on/off-road tread (40) for a passenger or light truck tire (10) of claim 4 wherein the net-to-gross ratio of the central zone (60) is greater than 50%.

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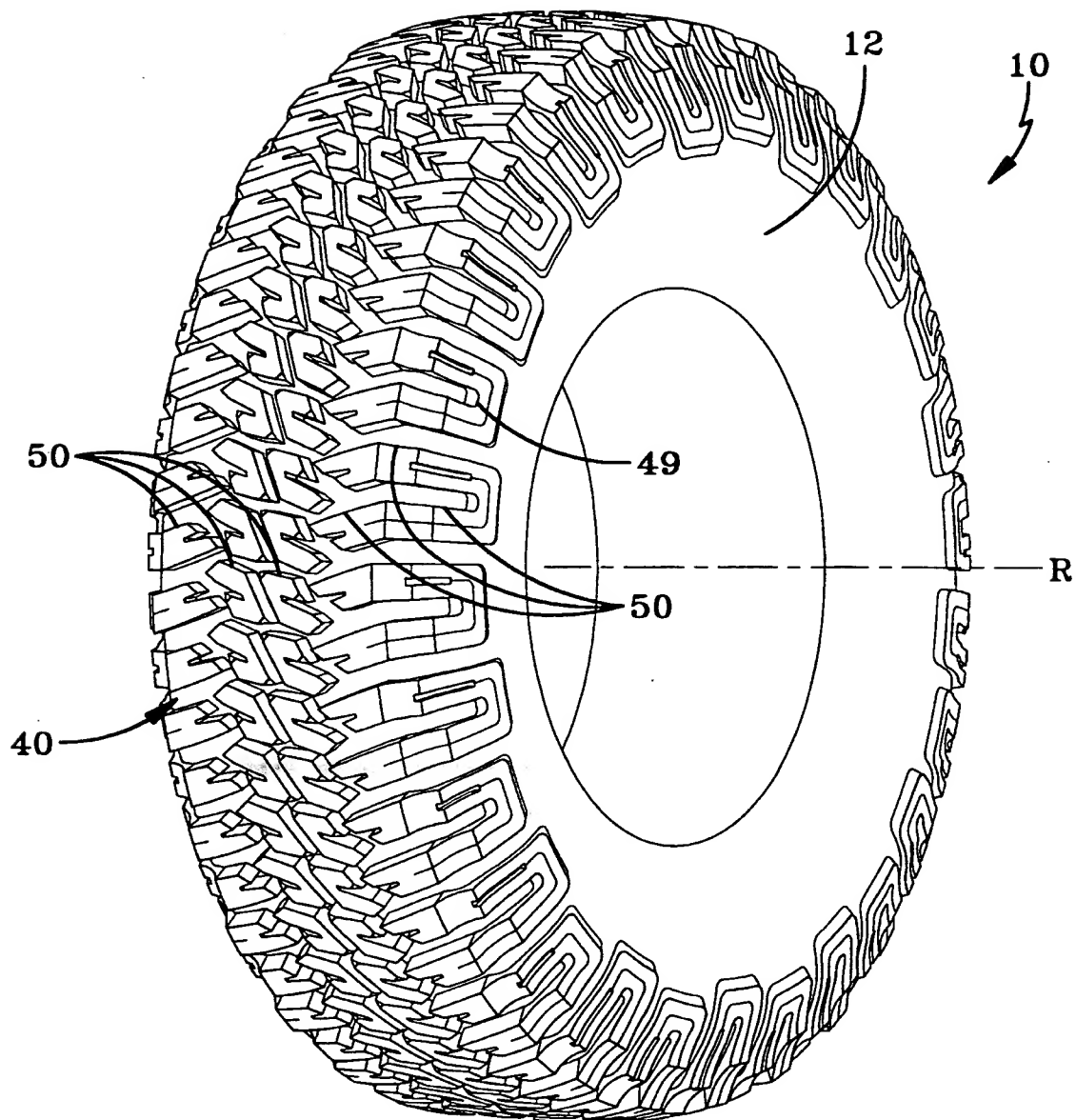


FIG-1

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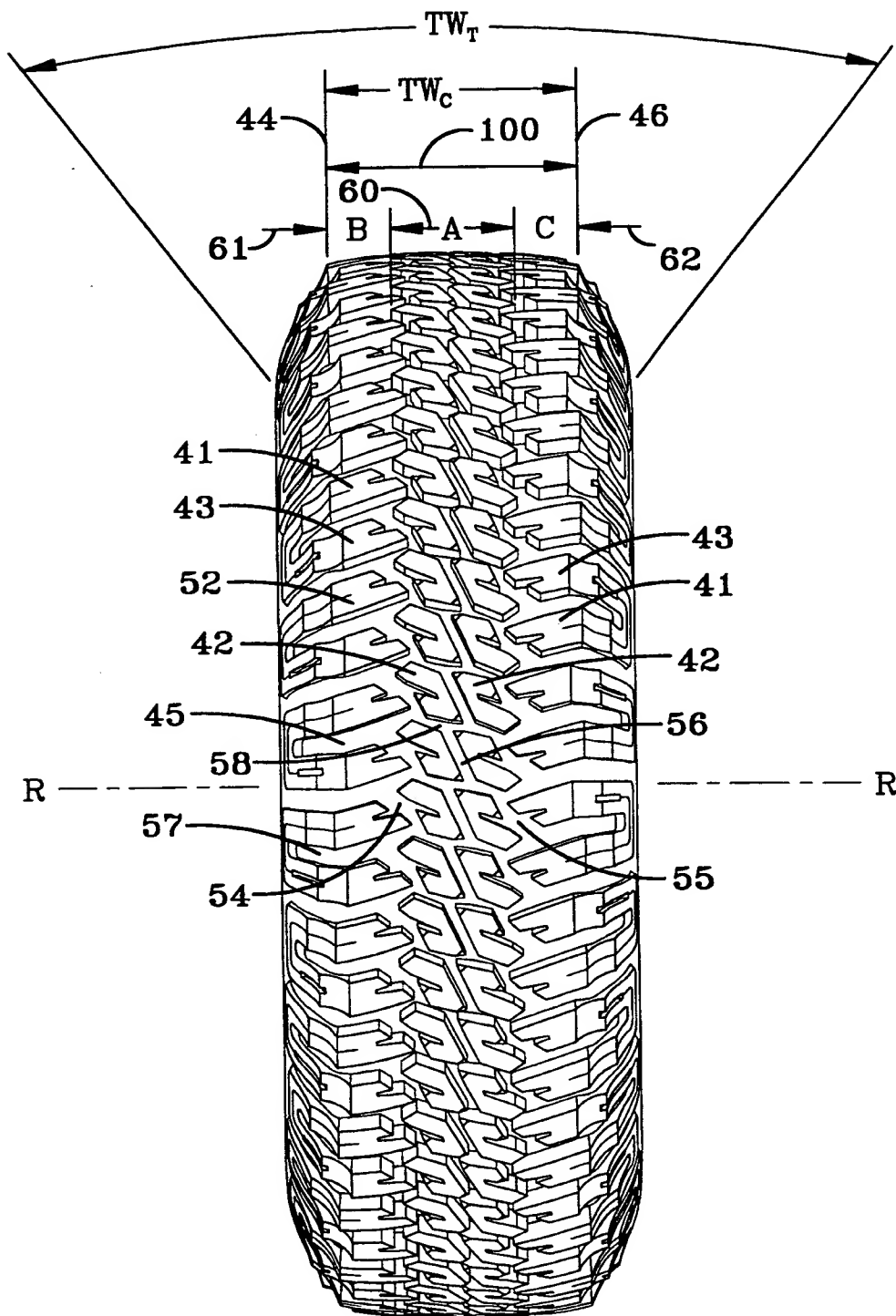


FIG-2

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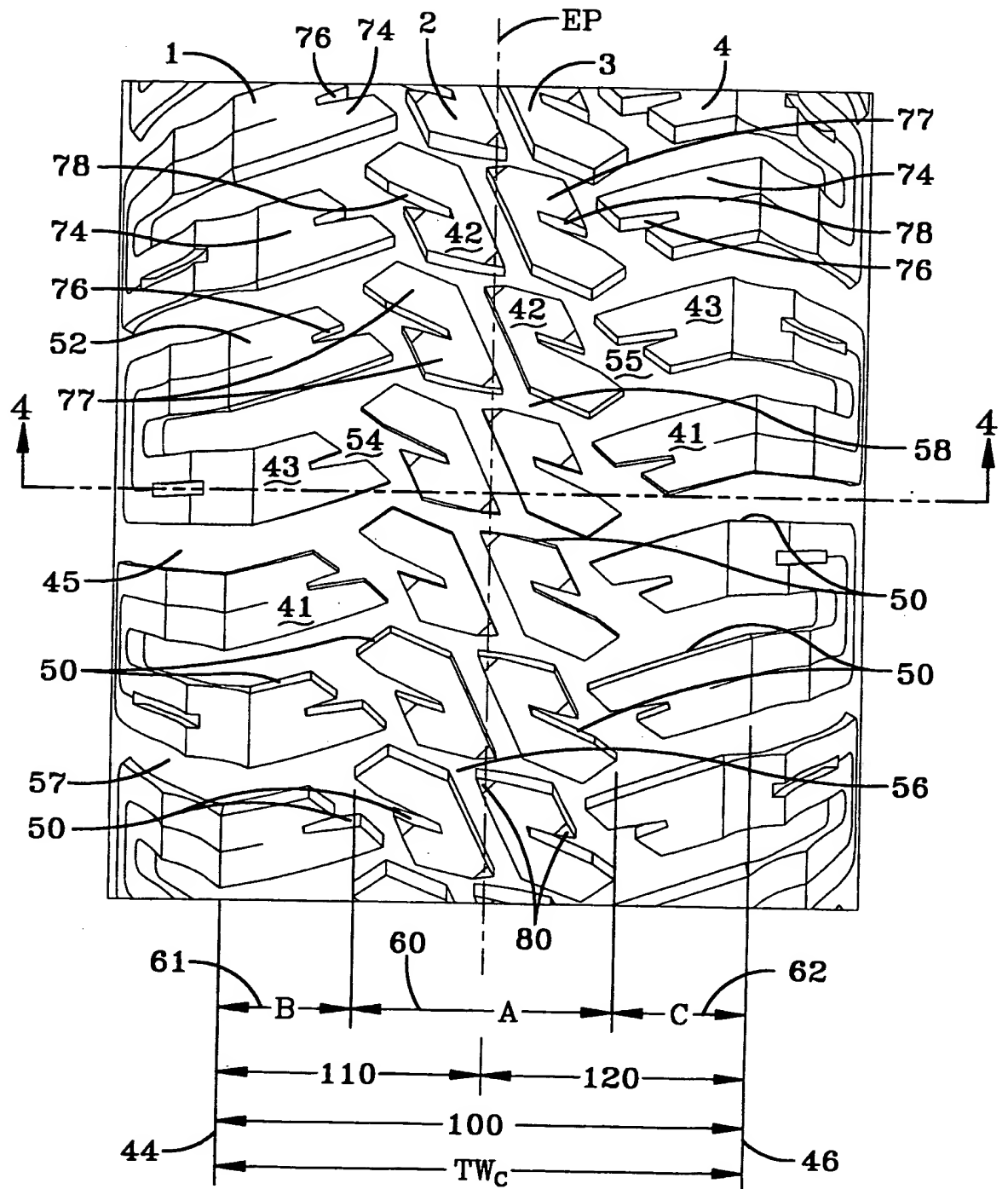
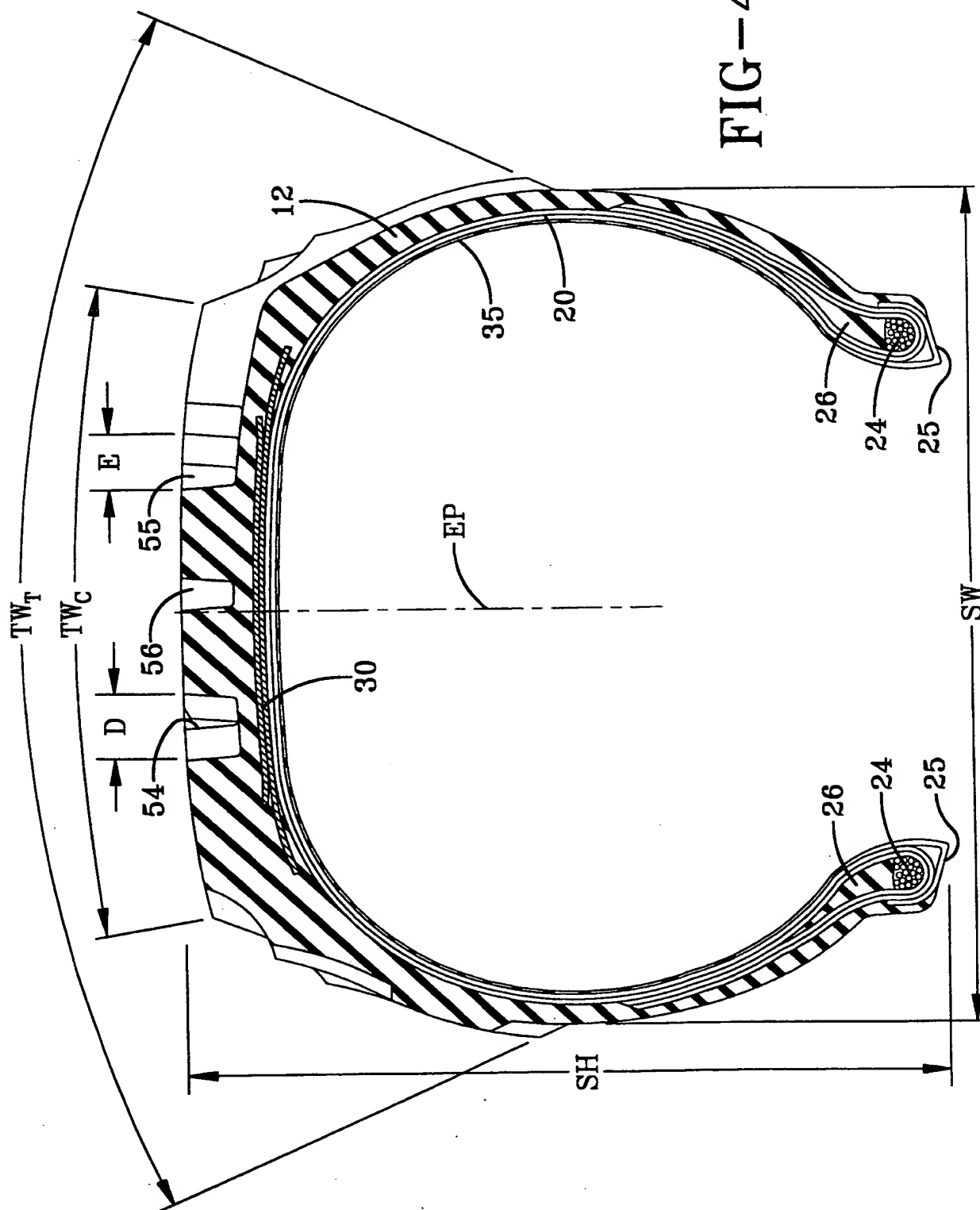


FIG-3

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FIG-4



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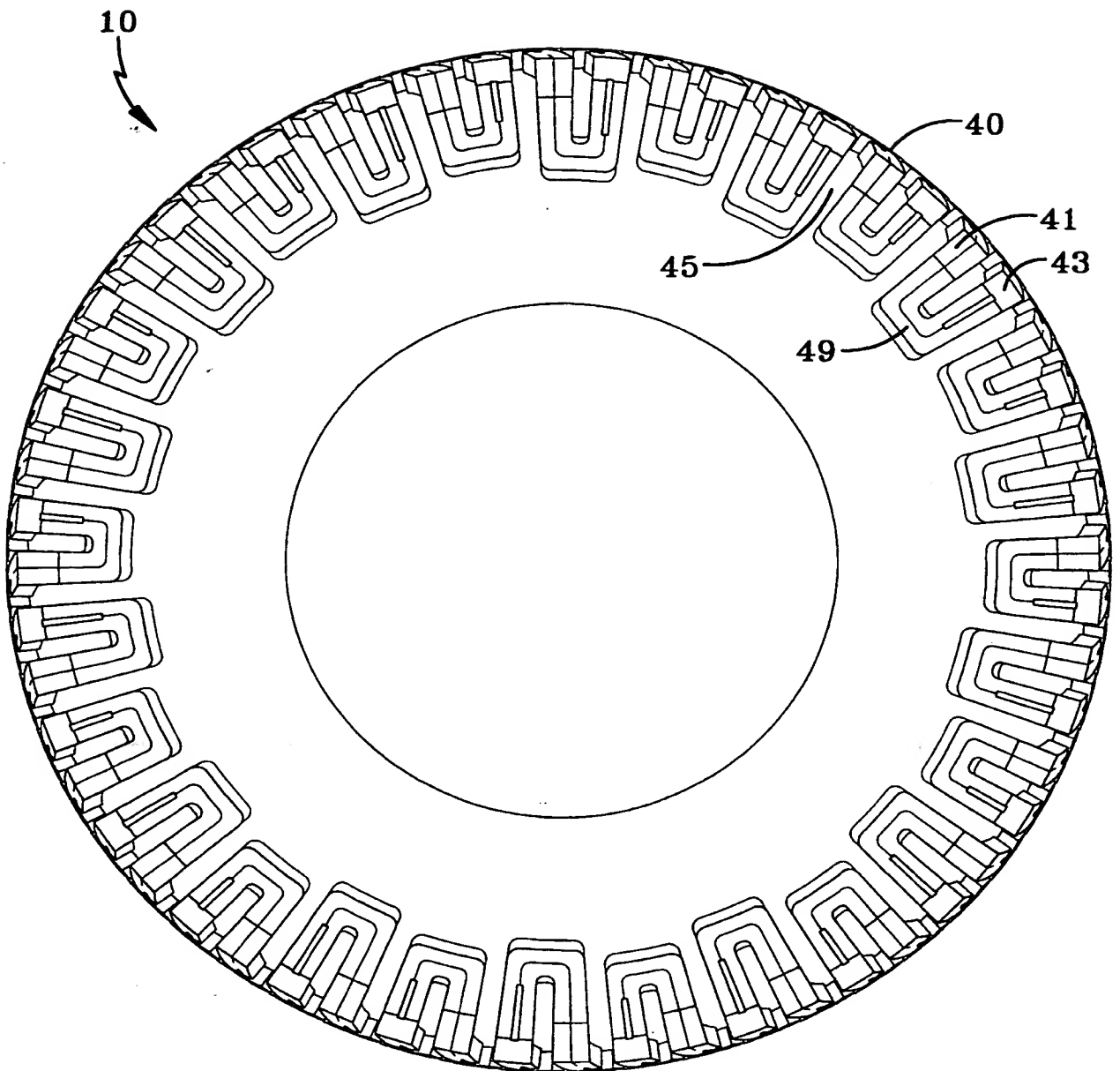


FIG-5

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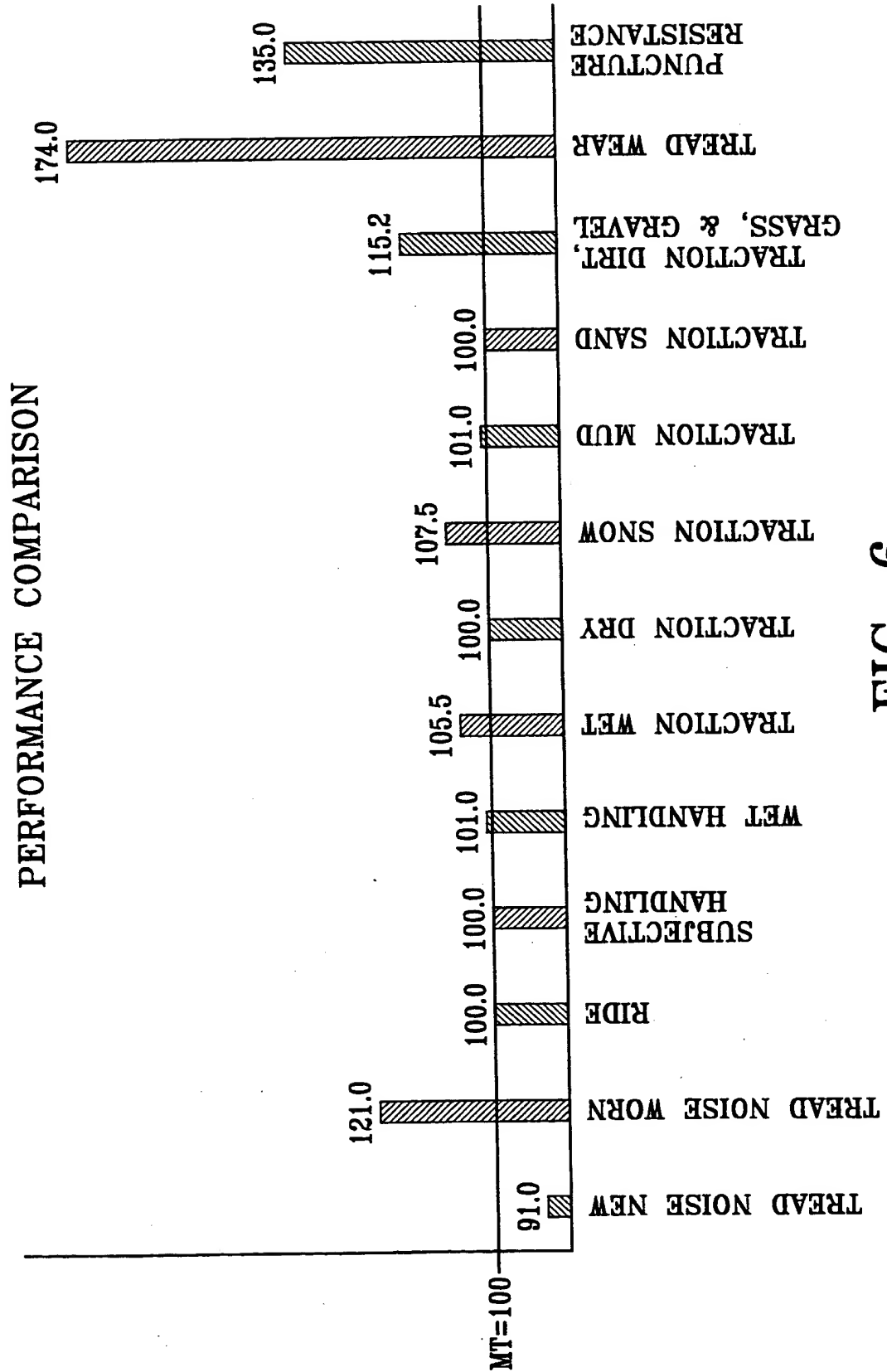


FIG-6

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/04533

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 B60C11/11 B60C11/01 B60C11/00 //B60C103:00,B60C121:00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 B60C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 014, no. 473 (M-1035), 16 October 1990 & JP 02 189206 A (SUMITOMO RUBBER IND LTD), 25 July 1990	1
Y	see abstract	2-4, 6
A	see figures	5
X	PATENT ABSTRACTS OF JAPAN vol. 015, no. 160 (M-1105), 22 April 1991 & JP 03 031008 A (OHTSU TIRE & RUBBER CO LTD:THE), 8 February 1991 see abstract	1
	--- -/-	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

21 June 1999

Date of mailing of the international search report

28/06/1999

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INTERNATIONAL SEARCH REPORT

Inter. nal Application No
PCT/US 99/04533

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 273 056 A (SUMITOMO RUBBER IND) 6 July 1988 see page 2, line 27 - line 47 see page 4 see figures 1,2 ----	1
Y	EP 0 467 146 A (GOODYEAR TIRE & RUBBER) 22 January 1992 cited in the application A see column 5, line 27 - column 6, line 18 see figures ----	2-4,6 1
A	EP 0 543 661 A (SUMITOMO RUBBER IND) 26 May 1993 see page 3, line 21 - line 30 see figures 1-3 ----	1,3,5
A	WO 98 08697 A (BONKO MARK LEONARD ;GOODYEAR TIRE & RUBBER (US)) 5 March 1998 see page 7, line 19 - line 29 see figures 2,4 ----	1,3,5
A	US 5 343 914 A (WAKO IWAMURA) 6 September 1994 see column 3, line 27 - line 30 see figures 1,2 -----	1,2

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 99/04533

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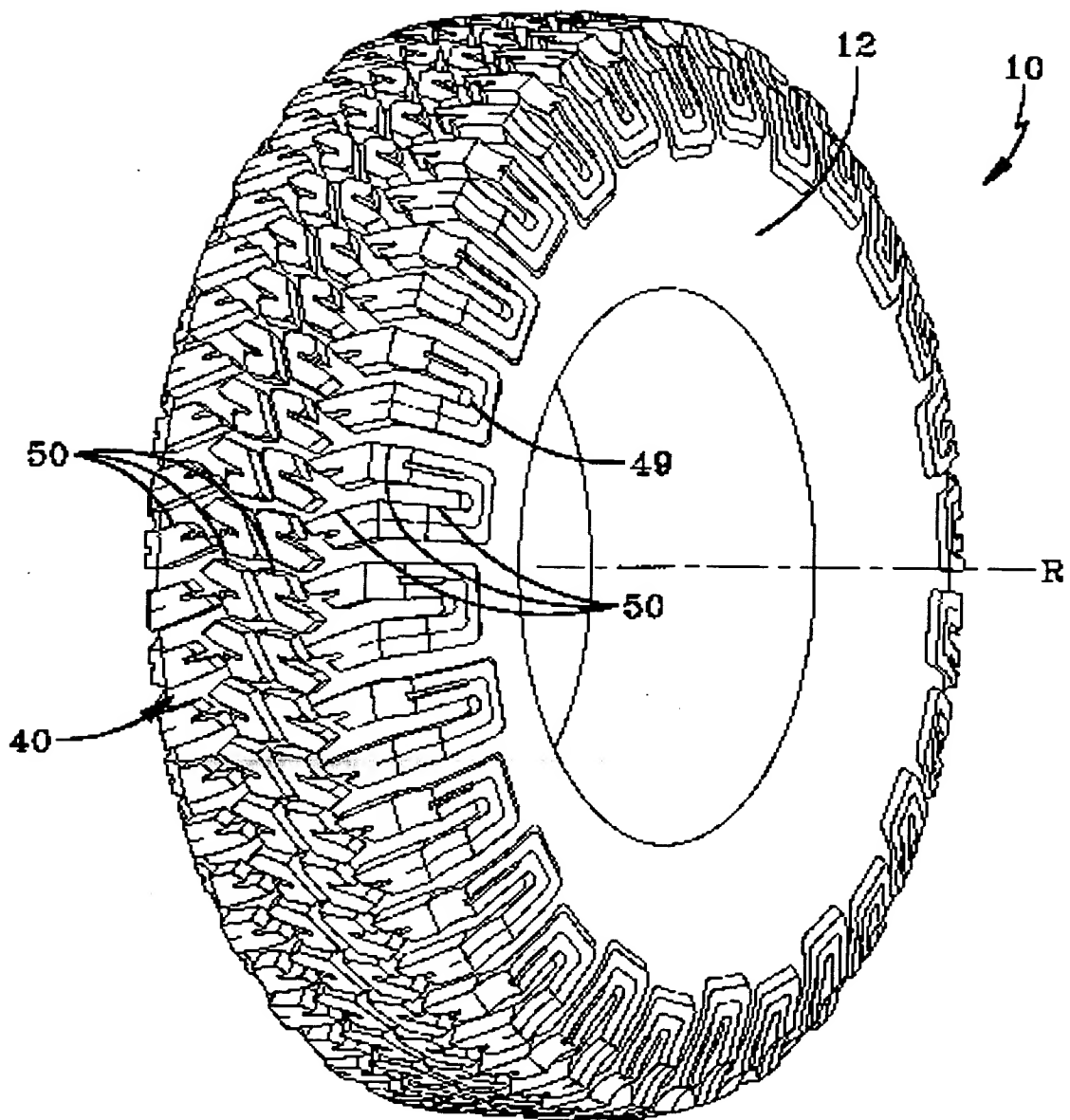


FIG-1

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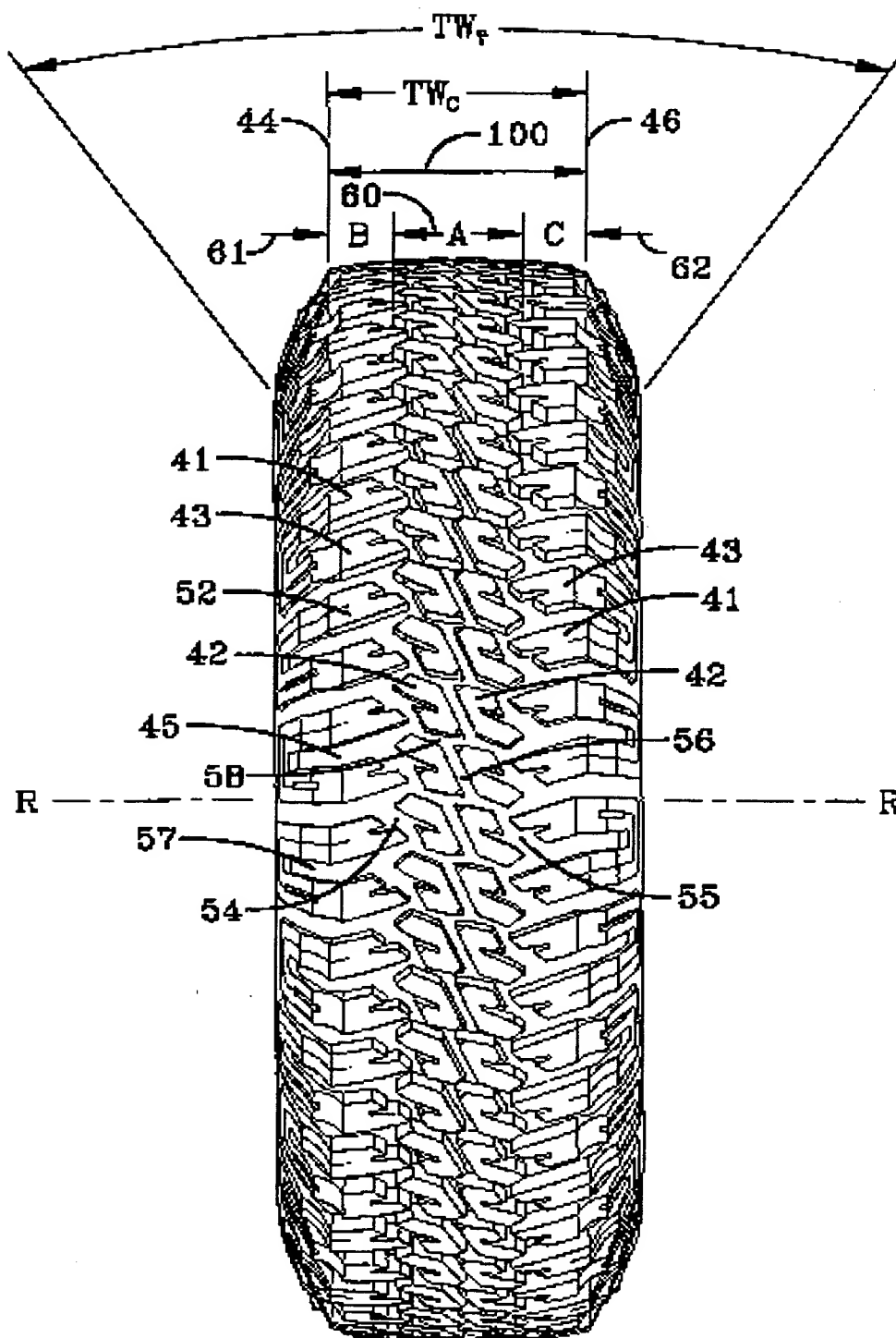


FIG-2

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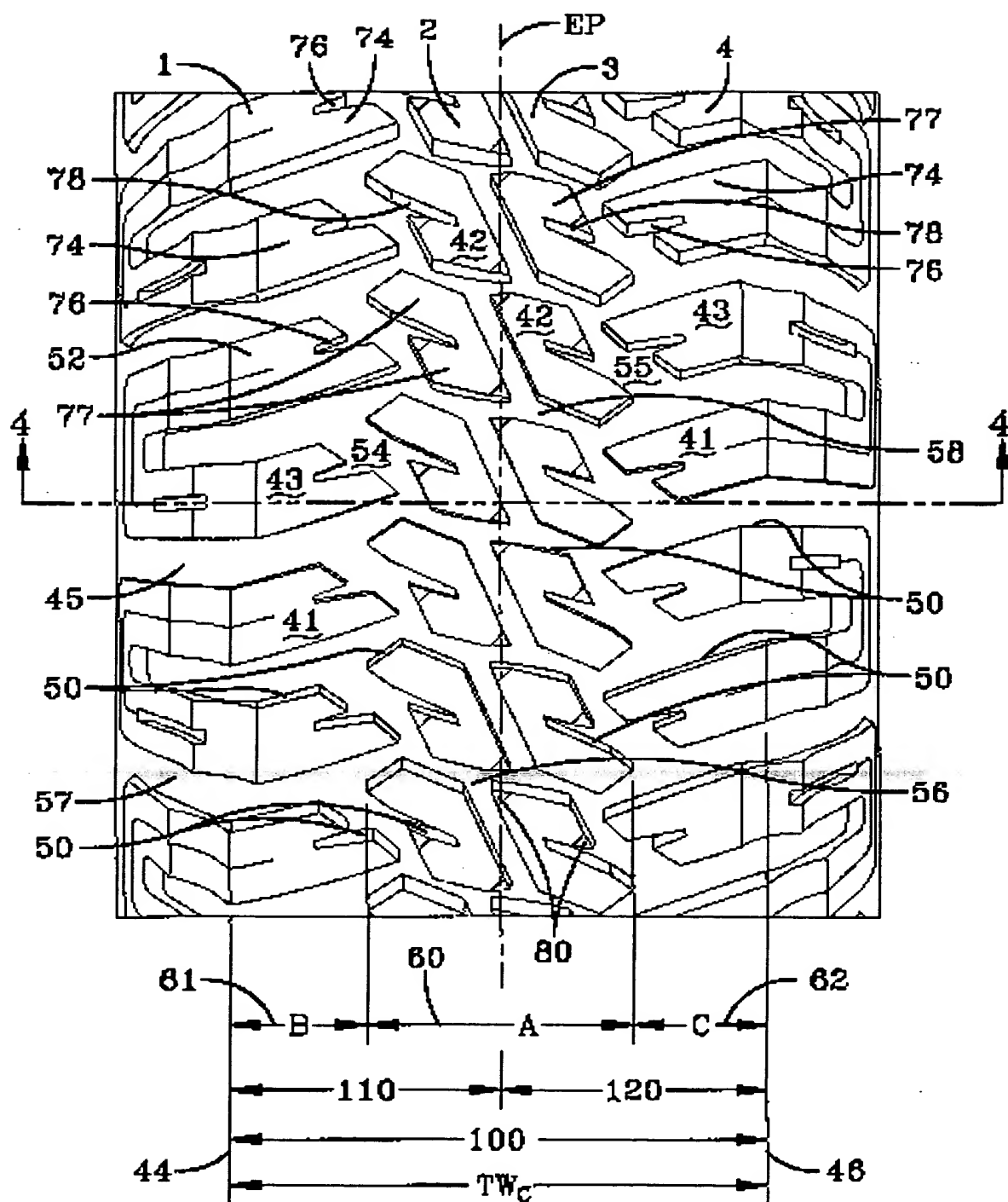
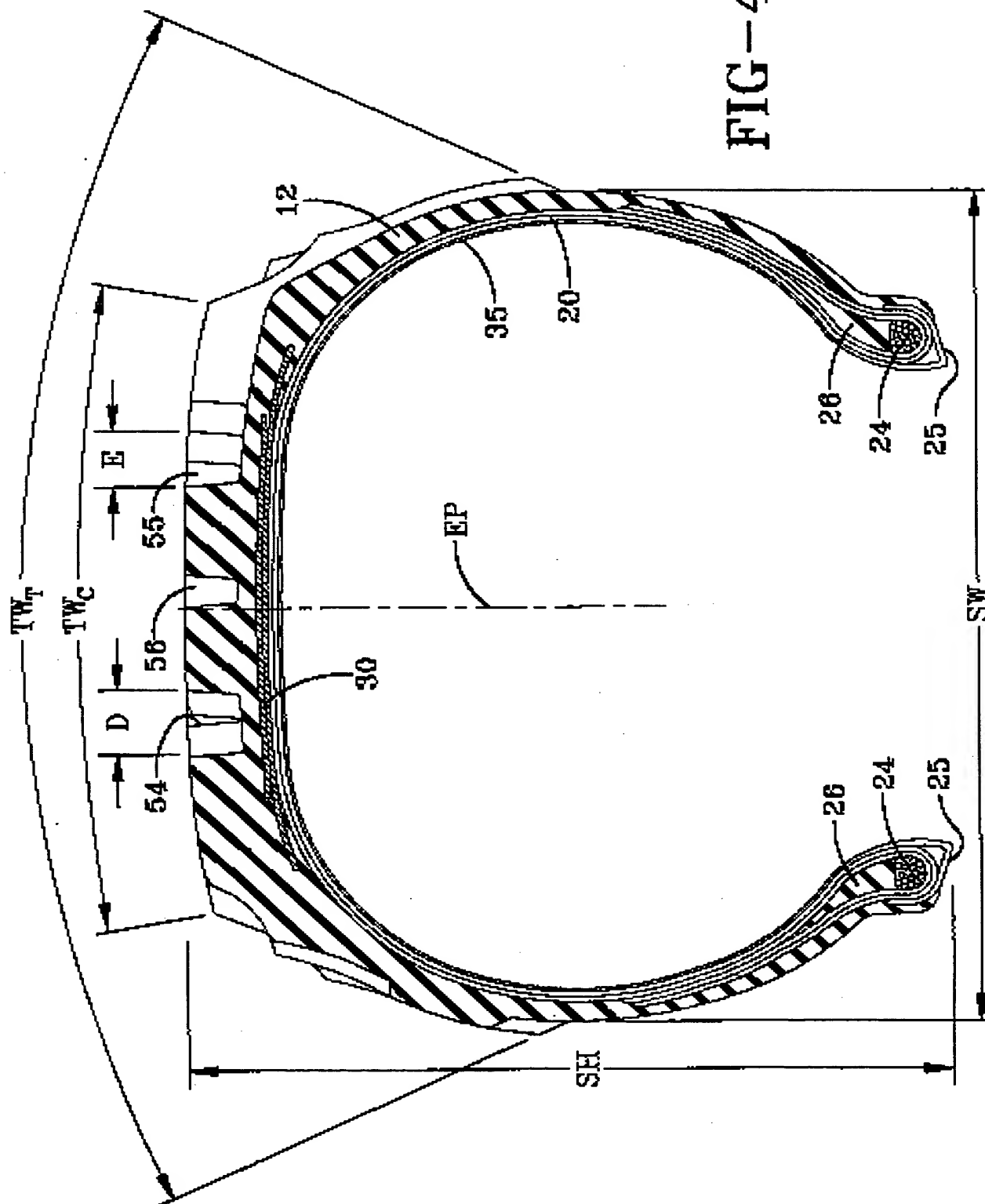


FIG-3

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FIG-4



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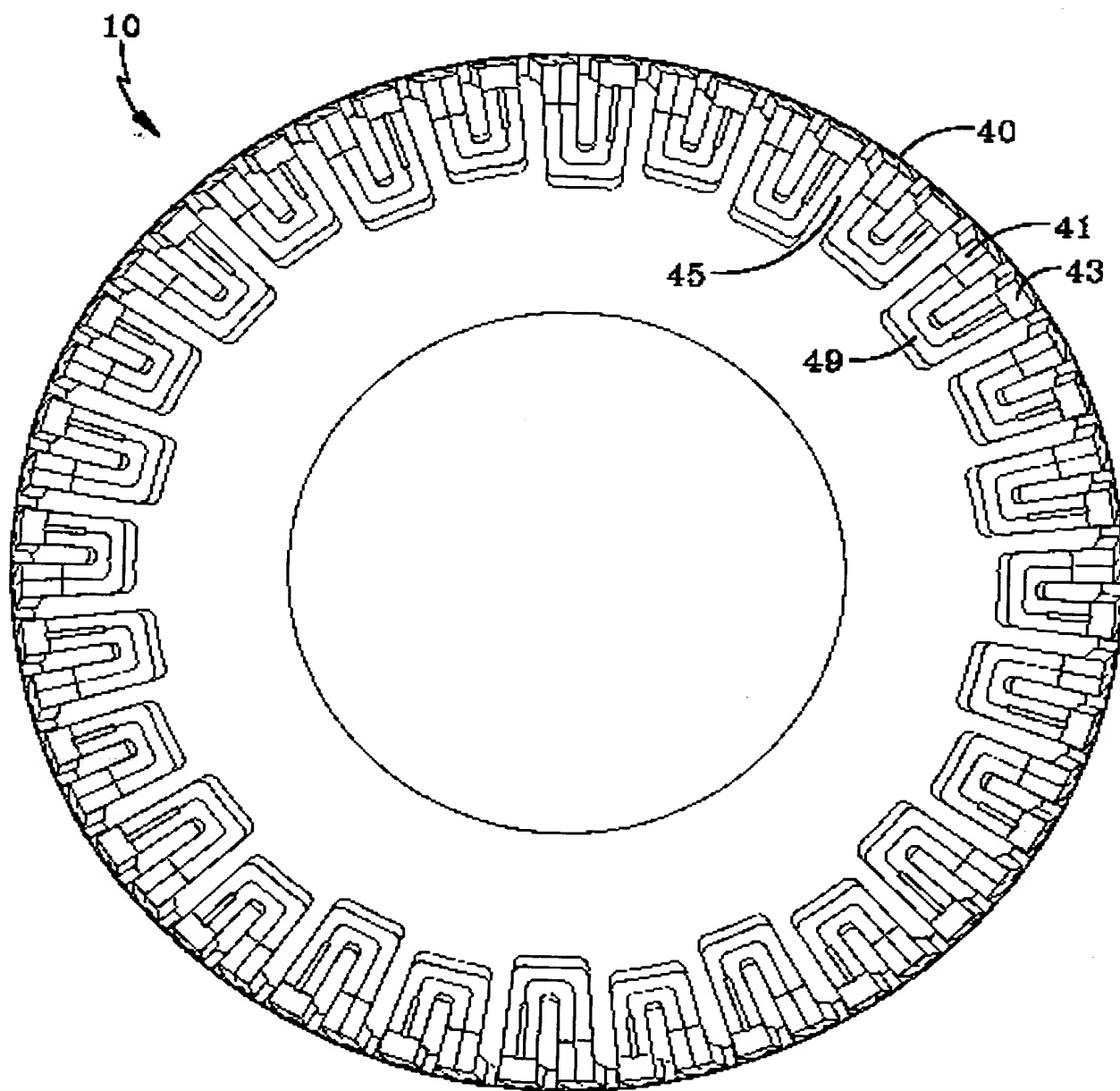


FIG-5

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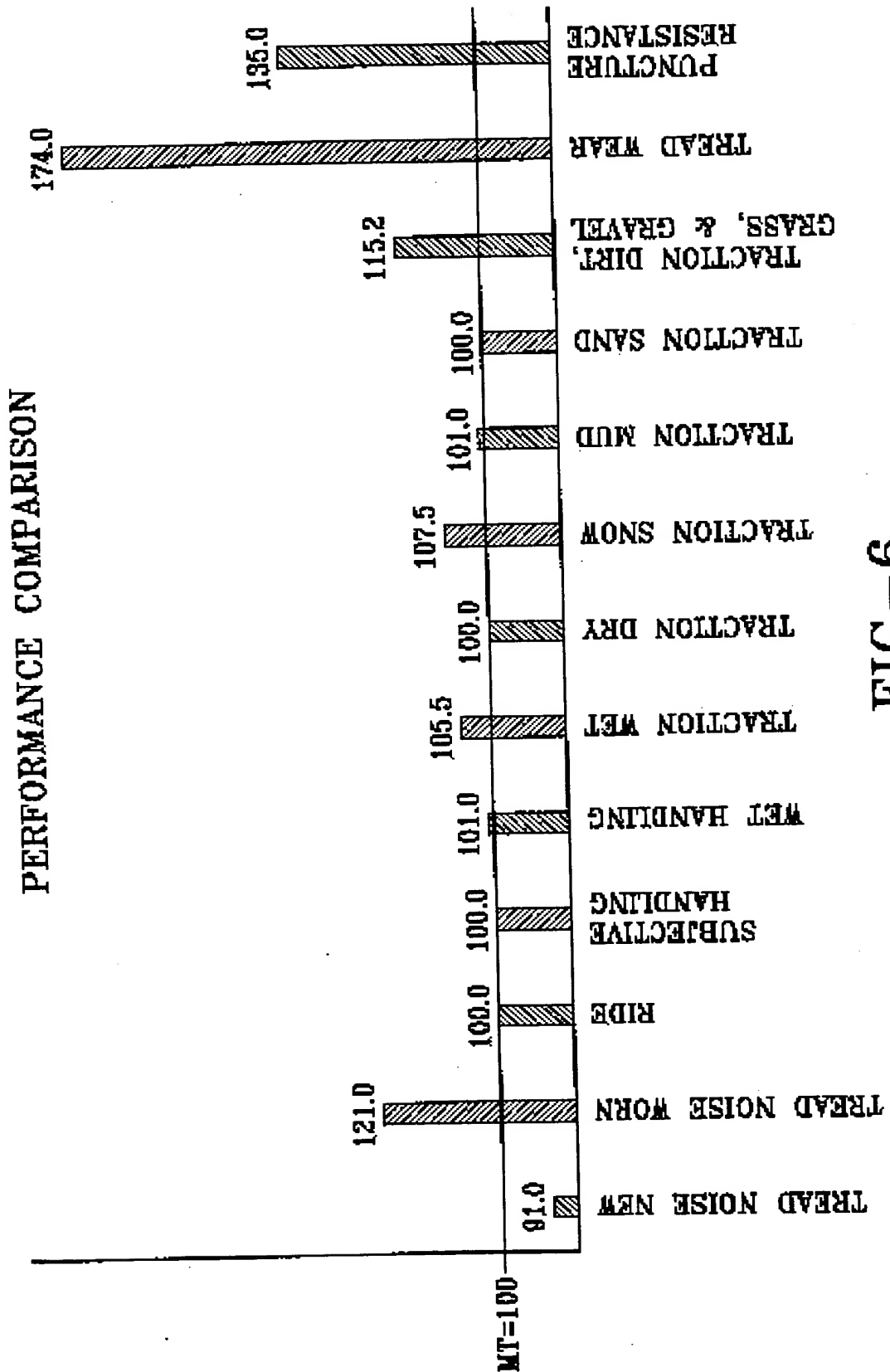


FIG-6